

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification 5 :</b> <b>C01B 33/146, D21H 21/10, 17/74</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 91/07351</b> <b>(43) International Publication Date:</b> 30 May 1991 (30.05.91)
<b>(21) International Application Number:</b> PCT/SE90/00690 <b>(22) International Filing Date:</b> 24 October 1990 (24.10.90) <b>(30) Priority data:</b> 8903754-3 9 November 1989 (09.11.89) SE <b>(71) Applicant (for all designated States except US):</b> EKA NOBEL AB [SE/SE]; S-445 01 Bohus (SE). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> JOHANSSON, Hans, Erik [SE/SE]; Madångsgatan 5, S-442 33 Kungälv (SE). LARSSON, Bo, Valdemar [SE/SE]; Bergsvägen 8, S-433 61 Partille (SE). <b>(74) Agent:</b> SCHÖLD, Zaid; Nobel Industries Sweden AB, Patent Department, Box 11554, S-100 61 Stockholm (SE).		<b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), US.  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> SILICA SOLS, A PROCESS FOR THE PRODUCTION OF SILICA SOLS AND USE OF THE SOLS  <b>(57) Abstract</b>  Silica sols which have a large alkali excess, i.e. a low molar ratio $\text{SiO}_2$ to $\text{M}_2\text{O}$ , and which contain silica particles with a high specific surface area. The silica sols can be prepared through acidification of a water glass solution and subsequent alkalization of the acid sol to the molar ratio in question. The sols are particularly suitable for use as additives, in combination with cationic polymers, in papermaking.		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	SD	Sudan
CF	Central African Republic	KP	Democratic People's Republic of Korea	SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LJ	Liechtenstein	SU	Soviet Union
CI	Côte d'Ivoire	LK	Sri Lanka	TD	Chad
CM	Cameroon	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark	MG	Madagascar		
ES	Spain				

Silica sols, a process for the production of silica sols and use of the sols

The present invention relates to new silica sols, to a process suitable for the production of the sols and to the use of the new sols in the production of paper. More particularly the invention relates to new silica sols which have particles with a high specific surface area and which have a fairly low molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , ie a fairly high excess of alkali. The new sols are particularly suitable for use in the production of paper as additives in combination with cationic polymers.

Silica sols, which term is used herein for silica hydrosols, are aqueous systems with very small silica particles which can be used in several fields of application, among other things dependent on the particle size. At the production of paper silica based sols with anionic particles have gained an increased utilization during the last few years. The silica sols are here used as additives to the stock in combination with cationic polymers, primarily to increase retention and dewatering at papermaking. In the European patent 41056 is for example disclosed the use of colloidal silica sols in combination with cationic starch in the production of paper. It is stated in a general manner that the silica particles have a specific surface area within the range of from 50 to 1000  $\text{m}^2/\text{g}$ . It is further generally stated for the sols that they have been stabilized with alkali to a molar ratio of  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  of 10:1 to 300:1, and preferably to a ratio of 15:1 to 100:1. The at production of paper commercially used sols are of the type which have a colloidal particles with a particle size usually from about 4 to about 7 nm, ie a specific surface area of from about 700 to about 300  $\text{m}^2/\text{g}$  and above all sols with particles having a specific surface area of about 500  $\text{m}^2/\text{g}$  have been used commercially. It has generally been considered that sols with colloidal particles of the above given size have given the best results and they have also been preferred with regard to their stability. The commercial sols have usually had a molar

ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  of about 40:1, ie they have been stabilized with smaller amounts of alkali. Attempts have been made, as evident from the mentioned European patent, to prepare silica sols with particles which have a high specific surface area. However, these have not been sufficiently stable to be used on a larger scale.

According to the present invention it has been found that silica sols with particles which have a high specific surface area are stable and that the high specific surface area can be maintained within a high range for sufficiently long times to enable commercial handling through the fact that the sols have a certain molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ .

The present invention thus relates to new silica sols which are characteristic in that they contain particles which have a comparatively high specific surface area and in that they have a comparatively low molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  (where M stands for alkali metal ion and/or ammonium ion and M preferably means a sodium ion), ie a comparatively high alkali content. It has been found that these sols which contain anionic particles are useful at the production of paper and similar products and that they hereby, in combination with cationic polymers, give very good improvement of retention and dewatering. In addition to silica sols as defined in the appended claims the present invention also relates to a process for the production of silica sols and to the use of the sols, as defined in the appended claims.

As has been mentioned above, the present silica sols are characteristic in that the silica particles have a comparatively high specific surface area and this is within the range of from 700 to 1200  $\text{m}^2/\text{g}$ . The given specific surface area has been measured by means of titration with NaOH according to the method described by Sears in Analytical Chemistry 28(1956):12, 1981-1983. The silica sols according to the invention are further characteristic in that they have a comparatively low molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , within the range of from 6:1 to 12:1, and suitably within the range of from 7:1 to 10:1. As the sols have the

given molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , ie a large excess of alkali, they are stable both towards gelation and towards substantial decrease of the specific surface area for sufficiently long times so that they can be handled, transported and used in a commercial manner and this at concentrations which are suitable with regard to these aspects. The molar ratio must not be below 6:1 with regard to the risk for gelation which arises if this limit is passed. The limit 12:1 is essential for maintaining the high specific surface area of the particles. The present sols suitably have a dry substance content, calculated as  $\text{SiO}_2$ , of from about 3 to about 15 per cent by weight, and they preferably have a dry substance content within the range of from 5 to 12 per cent by weight.

The sols according to the invention can be prepared starting from conventional alkali water glasses, potassium or sodium water glass, preferably from sodium water glass. The mole ratio of  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  or  $\text{K}_2\text{O}$ , in the water glass can, as per se known, be within the range of from 1.5:1 to 4.5:1 and is preferably within the range of from 3.2:1 to 3.9:1. A diluted solution of the water glass is utilized and this suitably has an  $\text{SiO}_2$  content of from about 3 to about 12 per cent by weight, preferably from about 5 to about 10 per cent by weight. The water glass solution which usually has a pH around 13, or above 13, is acidified to a pH of from about 1 to about 4. The acidification can be carried out in per se known manner by addition of mineral acids, such as for example sulfuric acid, hydrochloric acid and phosphoric acid or optionally with other known chemicals for acidification of water glass such as ammonium sulfate and carbon dioxide. However, it is preferred that the acidification is carried out by means of acid cation exchangers which among other things lead to more stable products and give almost sodium free acid sols. The acidification is preferably carried out by means of strongly acid cation exchange resin, for example of sulfonic acid type. It is preferred that the acidification is carried out to a pH of from about 2.0 to 4.0 and most preferably from

about 2.2 to about 3.0. After acidification an alkalization of the acid sol is carried out to the given molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ . The obtained sol will hereby normally get a pH value above 10.5. The alkalization can be carried out with  
5 conventional alkali such as sodium, potassium or ammonium hydroxide. It is, however, preferred that alkalization is carried out by addition of water glass. Potassium and sodium water glass, particularly sodium water glass, with a mole ratio of  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  as above described is used in  
10 this alkalization step. The  $\text{SiO}_2$  content in the water glass solution used for the alkalization is not critical but is decided with regard to the desired dry substance content. The  $\text{SiO}_2$  content is suitably within the range of from about 5 to about 35 per cent by weight and preferably within the  
15 range of from 10 to 30. The acid sol has particles with a high specific surface area, above  $1000 \text{ m}^2/\text{g}$  and usually around  $1300 \text{ m}^2/\text{g}$ . After the alkalization a particle growth starts and thus a decrease of the specific surface area. However, since the sols have the given molar ratio  $\text{SiO}_2$  to  
20  $\text{M}_2\text{O}$  the surface area will be stabilized within the given range after a fairly short period of time, about a week, and be stable within this range for longer times, at least two months. According to the process silica sols with dry contents of from about 3 to about 15 per cent by  
25 weight, and suitably of from about 5 to about 12 per cent by weight, can be prepared.

The new sols, with anionic particles, according to the invention are particularly suitable at the production of paper. The present invention also relates to this use of  
30 the sols. As mentioned by way of introduction it is well known to use silica based sols in combination with cationic polymers at the production of paper, primarily in order to improve retention and drainage. The present silica sols are used in corresponding manner as earlier known for  
35 silica sols with anionic particles and they give, in combination with cationic polymers, a substantial improvement of retention and dewatering at paper production. Very good retention and dewatering results are obtained as a

result of the high specific surface area of the sols. The improved dewatering also means that the speed of the paper machine can be increased and further that less water need to be dried off in the press and drying sections of the paper machine and an economically substantially improved paper production process is hereby obtained. The very much decreased sol dosage, calculated as  $\text{SiO}_2$ , required to obtain corresponding results as with commercial sols should be particularly mentioned.

The present invention thus also relates to a method for the production of paper having the characteristic features set out in the claims. As cationic polymer according to the invention such polymers which are conventionally used in paper production as retention and/or wet strength agent are suitable and they can be natural, ie based on carbohydrates, or synthetic. As examples of suitable cationic polymers can be mentioned cationic starch, cationic guar gum, cationic polyacrylamides, polyethyleneimines, polyamidoamines and poly(diallyldimethyl ammonium chloride). The cationic polymers can be used separately or in combination with each other. Preferred cationic polymers are cationic starch and cationic polyacrylamide. According to a particularly preferred embodiment the silica sols are used in combination with both cationic starch and cationic synthetic polymer and particularly then cationic polyacrylamide.

The amount of silica sol and cationic polymer at paper production according to the present invention can vary within wide limits depending, among other things, on type of stock, presence of fillers and other conditions. The amount of sol should suitably be at least 0.01 kg/t, calculated as  $\text{SiO}_2$  on dry fibers and optional fillers, and is suitably within the range of from 0.05 kg/ton to 5 kg/ton and preferably within the range of from 0.1 to 2 kg/ton. The sol is suitably added to the stock with dry contents within the range of from 0.1 to 5 per cent by weight. The amount of cationic polymer is to a high degree dependent on the type of polymer and on other effects

desired from the polymer. For synthetic cationic polymers usually at least 0.01 kg/ton is used, calculated as dry on dry fibers and optional fillers. Suitably amounts of from 0.01 to 3 and preferably of from 0.03 to 2 kg/ton are used.

5 For cationic polymers based on carbohydrates such as cationic starch and cationic guar gum amounts of at least 0.1 kg/ton, calculated as dry on dry fibers and optional fillers, are usually used. For these polymers amounts of from 0.5 to 30 kg/ton are suitably used and preferably from

10 1 to 15 kg/ton. The weight ratio of cationic polymer to sol calculated as  $\text{SiO}_2$  should suitably be at least 0.01:1 and suitably at least 0.2:1. The upper limit for cationic polymer is primarily a question of economy and of charge. For polymers with lower cationicity such as cationic

15 starch, alone or in combination with other cationic polymers, very high amounts can thus be used, up to a ratio of 100:1 and higher, and the limit is mainly decided with regard to economy. For most systems suitable ratios cationic polymer to sol, calculated as  $\text{SiO}_2$ , is within the

20 range of from 0.2:1 to 100:1. When the silica sol is used together with a combination of cationic starch and cationic synthetic polymer, and preferably cationic polyacrylamide, the weight ratio between the two latter is suitably within the range of from 0.5:1 to 200:1 and preferably within the

25 range of from 2:1 to 100:1. The present silica sols can of course be used in the production of paper in combination with paper chemicals which are conventional in papermaking such as hydrophobing agents, dry strength agents, wet strength agents etc. It is particularly suitable to utilize

30 aluminum compounds in combination with the present sols and cationic polymers since it has been found that aluminum compounds can give an additional improvement of retention and dewatering. Any aluminum compound per se known for use in papermaking can be utilized, eg alum, polyaluminum

35 compounds, aluminates, aluminum chloride and aluminum nitrate. Also the amount of aluminum compound can vary within wide limits and it is suitable to use the aluminum compound in a weight ratio to the sol, calculated as  $\text{SiO}_2$ ,



of at least 0.01:1, whereby the aluminum compound has been calculated as  $\text{Al}_2\text{O}_3$ . The ratio should suitably not exceed 3:1 and is preferably within the range of from 0.02:1 to 1.5:1. The polyaluminum compounds can for example be  
5 polyaluminum chlorides, polyaluminum sulfates and polyaluminum compounds containing both chloride and sulfate ions. The polyaluminum compounds may also contain other anions than chloride ions, for example anions from sulfuric acid, phosphoric acid, organic acids such as citric acid and  
10 oxalic acid.

The silica sols and the cationic polymers can be utilized at the production of paper from different kinds of stocks of cellulose containing fibers and the stocks should suitably contain at least 50 per cent by weight of such  
15 fibers, calculated on dry material. The components can for example be used as additives to stocks from fibers from chemical pulp, such as sulphate and sulphite pulp, thermo-mechanical pulp, refiner mechanical pulp or groundwood pulp, from as well hardwood as softwood and can also be  
20 used for stocks based on recycled fibers. The stocks can also contain mineral fillers of conventional types such as kaolin, titanium dioxide, gypsum, chalk and talcum. The terms paper and paper production which are used herein do of course include not only paper but also other cellulose  
25 fiber containing products in sheet or web form, such as pulp sheets, board and paper board and their production.

The sols can be utilized within a wide pH range at paper production. The best effects are, however, obtained under neutral or alkaline conditions. It is thus preferred  
30 that the sol are utilized in paper production where the pH of the stock is 6 or higher. Even if any order of addition can be used it is preferred that the cationic polymer is added before the sol. If both cationic starch and cationic synthetic polymer are used it is preferred that they are  
35 added in this order.

The present invention is further illustrated in the following examples which, however, are not intended to limit the same. Parts and per cent relate to parts by

weight and per cent by weight, respectively, unless otherwise stated.

Example 1A-1C

In these examples the preparation of the new sols is described.

Example 1A

5000 g of a water glass solution with a molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  of 3.49:1 and an  $\text{SiO}_2$  content of 5.75% was ion exchanged by pumping it through a column filled with cation ion exchange resin Amberlite IR-120.

To 1000 g of the obtained acid sol with an  $\text{SiO}_2$  content of 5.58% 146 g of a water glass solution with a molar ratio of 3.49:1 and an  $\text{SiO}_2$  content of 24.8% were added under stirring.

The obtained sol A had a final molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  of 8.8:1 and the specific surface area of the particles, measured after a week, was  $1010 \text{ m}^2/\text{g}$ . The sol was stable towards gelation for several months. The specific surface area of the particles was measured after about 1 month and was then about  $920 \text{ m}^2/\text{g}$ . When measured after about 2 months the specific surface area was still as high as  $875 \text{ m}^2/\text{g}$ .

Example 1B

A water glass solution was ion exchanged in a column according to Example 1A so that an acid sol with an  $\text{SiO}_2$  content of 4.84% was obtained. To 900 kg of the acid sol 97.5 kg of a water glass solution with an  $\text{SiO}_2$  content of 24.8% and a molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  of 3.49 were added.

The obtained sol B had a final molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  of 9.8:1 and the particles specific surface area, measured after 1 week, was  $980 \text{ m}^2/\text{g}$ .

Example 1C

A water glass solution was ion exchanged in a column to an acid sol having an  $\text{SiO}_2$  content of 4.71%. To 500 g portions of this acid sol varying amounts of water glass with an  $\text{SiO}_2$  content of 22.8% and  $\text{Na}_2\text{O}$  content of 6.5% were added. In the Table below the specific surface area for the sols, measured one week after the preparation, and

the final molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  in the sols are shown.

Sol	Amount of water-glass g	Specific surface area $\text{m}^2/\text{g}$	Molar ratio $\text{SiO}_2:\text{Na}_2\text{O}$
C1	55	960	10.1
5 C2	65	1020	9.1
C3	75	1060	8.3
C4	90	1120	7.5
C5	100	1145	7.1
C6	120	1175	6.5
10 <u>Example 2a) - 2d)</u>			

In the following tests the new sols were evaluated in the production of paper in combination with cationic polymers.

The dewatering effect was evaluated in a Canadian Standard Freeness (CSF) Tester according to SCAN-C 21:65. Additions of chemicals were made to a Britt Dynamic Drainage Jar with blocked outlet at 800 rpm for 45 seconds and the stock system was then transferred to the freeness tester. The dewatering results are given as ml CSF.

20 Example 2a

In this example the dewatering effect of sols A and B was investigated. The stock was a mixture of 60% bleached birch sulfate and 40% bleached pine sulfate. 30% of chalk were added to the stock as filler and a stock with a concentration of 3 g/l was then prepared and to this 1g/l of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  was added. The pH of the stock was 7.5 and its CSF value was 310 ml. As cationic polymer in the tests cationic starch which had a degree of substitution of 0.04 was used and added in amount of 5 kg/ton, based on dry fibers and fillers. When solely cationic starch was added in an amount of 5 kg/ton a CSF value of 360 ml was obtained. In the tests shown below the cationic starch was added before the sol. As a comparison a commercial silica sol as disclosed in the European patent 41056 which had a specific surface area of  $500 \text{ m}^2/\text{g}$  and molar ratio  $\text{SiO}_2$  to  $\text{Na}_2\text{O}$  of about 40:1 was used.

10

	Sol A	Sol B	Commercial	CSF
	kg/t	kg/t	sol kg/t	ml
	0.25			460
	0.5			490
5	0.75			495
		0.25		425
		0.5		455
		0.75		470
			0.25	390
10			0.5	420
			0.75	435

As evident either a higher effect can be obtained at the same dosage or a much lower dosage can be used to obtain the same results as with the commercial sol. The values shown in the Table relate to sol A and B as after storage for one week. After two months storage the sols gave corresponding improvements in comparison with the commercial sol.

#### Example 2b

In this example the effect of sol A in combination with a number of different cationic polymers was investigated. The cationic polymers were: cationic guar gum with a degree of substitution of about 0.12 (GUAR), cationic polyacrylamide with medium high charge and high molecular weight (PAM) and cationic poly(diallyldimethyl ammonium chloride) (Poly(DADMAC)). The same type of stock as in Example 2a) was used. However, the original CSF value for the stock was 255 ml. The cationic polymer was in all tests added to the stock before the sol. A comparison with the same commercial sol as in Example 2A was also made.

	GUAR	PAM	Poly(DADMAC)	Sol A	Commercial	CSF
	kg/t	kg/t	kg/t	kg/t	sol kg/t	ml
	2.5					310
	2.5			0.75		375
35	2.5			1.0		400
	2.5				0.75	335
	2.5				1.0	350

11

	GUAR kg/t	PAM kg/t	Poly(DADMAC) kg/t	Sol A kg/t	Commercial sol kg/t	CSF ml
		0.5				330
		0.5		0.75		415
5		0.5		1.0		435
		0.5		1.5		430
		0.5			0.75	350
		0.5			1.0	360
		0.5			1.5	375
10			0.25			270
			0.25	1.0		335
			0.25		1.0	295

Example 2c

In this example the dewatering effect of sols C1 to C6 in combination with cationic starch was investigated. The stock was a groundwood stock with a concentration of 3 g/l and a pH of 8.6. The cationic polymer was added before the sol and the sols were about one week old at the tests. Without addition of chemicals the stock had a freeness value of 180 ml. With addition of solely 7 kg/t of cationic starch the freeness value was 265 ml. When 7 kg of cationic starch and 1 kg of sol, the amounts being calculated as dry on 1 ton of dry fibers, were used the following results were obtained.

- 25 Cationic starch + Sol C1: 320 ml CSF
- Cationic starch + Sol C2: 323 ml CSF
- Cationic starch + Sol C3: 323 ml CSF
- Cationic starch + Sol C4: 325 ml CSF
- Cationic starch + Sol C5: 330 ml CSF
- 30 Cationic starch + Sol C6: 340 ml CSF

To the same groundwood stock as above 0.2 kg/t of a cationic polyacrylamide were added and a freeness value of 225 ml was then obtained. When the corresponding amount of cationic polyacrylamide was used in combination with 1.0 kg/t of sol C2 a freeness value of 235 was obtained and when a combination of cationic starch (7 kg/t), cationic polyacrylamide (0.2 kg/t) and sol C2 (1.0 kg/t) were used the freeness value was 390.

Example 2d

In this example retention properties were evaluated by means of a Britt Dynamic Drainage Jar at 800 rpm. This is the conventional test method for retention in paper industry.

The stock was made up from 60% bleached birch sulfate and 40% bleached pine sulfate. 30% of chalk were added to the stock as filler and it was then diluted to a concentration of 5 g/l. Then 1 g/l of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  was added. The stock had a fines fraction of 37.2% and a pH of 7.5.

The sol (C4) used in these retention tests was sol C4 according to Example 1C. The dosage order for the chemicals was cationic polymer followed by silica sol. In the test when both cationic starch (CS) and cationic polyacrylamide (PAM) were used these were added in this order. Comparisons with the same commercial sol as in Example 2A was also made. The results are shown below.

Test	CS	PAM	Sol C4	Commercial	Retention
No.	kg/t	kg/t	kg/t	sol kg/t	%
20	1	8	-	-	43.5
	2	8	-	0.75	72.0
	3	8	-	1.0	78.0
	4	8	0.75	-	81.8
	5	8	1.0	-	84.7
25	6	8	0.3	1.0	92.2

Claims

1. Silica sol, characterized in that the sol has a molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , where M is alkali metal ion and/or ammonium ion, within the range of from 6:1 to 12:1 and in  
5 that it contains silica particles with a specific surface area within the range of from 700 to 1200  $\text{m}^2/\text{g}$ .

2. Silica sol according to claim 1, characterized in that the sol has a molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  within the range of from 7:1 to 10:1.

10 3. A process for the production of a silica sol, characterized in that a water glass solution is acidified to a pH within the range of from 1 to 4 whereafter the obtained acid sol is alkalized to a molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , where M is alkali metal ion and/or ammonium ion,  
15 within the range of from 6:1 to 12:1.

4. A process according to claim 3, characterized in that the alkalization is carried out through addition of a water glass solution.

20 5. A process for the production of paper from a suspension of cellulose containing fibers, and optional fillers, whereby cationic polymer and anionic silica sol are added to the suspension and the suspension is formed and dewatered on a wire, characterized in that to the suspension is added cationic polymer and a sol which has a  
25 molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$ , where M is alkali metal ion and/or ammonium ion, within the range of from 6:1 to 12:1 and which contains silica particles having a specific surface area within the range of from 700 to 1200  $\text{m}^2/\text{g}$ .

30 6. A process according to claim 5, characterized in that the sol has a molar ratio  $\text{SiO}_2$  to  $\text{M}_2\text{O}$  within the range of from 7:1 to 10:1.

35 7. A process according to claim 5 or 6, characterized in that to the suspension is added sol and a cationic polymer which is cationic starch or cationic polyacrylamide.

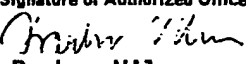
8. A process according to claim 5 or 6, characterized in that to the suspension is added sol, cationic starch and a cationic synthetic polymer.

9. A process according to claim 8, characterized in that the cationic synthetic polymer is cationic polyacrylamide.



# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 90/00690

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: C 01 B 33/146, D 21 H 21/10, D 21 H 17/74		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC5	C 01 B; D 21 H	
Documentation Searched other than Minimum Documentation to the extent that such Documents are Included in Fields Searched <sup>8</sup>		
SE,DK,FI,NO classes as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X,P	SE, A, 8803065-5 (NOBEL INDUSTRIES PAPER CHEMICALS AB) 2 March 1990, see page 3 --	1-2
X	EP, A1, 0041056 (EKA AB) 2 December 1981, see page 8; abstract --	1-7
X	WO, A1, 8806659 (EKA NOBEL AB) 7 September 1988, see page 3; abstract --	1-7
Y	--	5-9
Y	EP, A1, 0261820 (E.I. DU PONT DE NEMOURS AND COMPANY) 30 March 1988, see page 6, line 1 - line 20; page 9; abstract; claims 1,8-18 --	5-9
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>*</sup> Special categories of cited documents: <sup>10</sup></p> <p><sup>"A"</sup> document defining the general state of the art which is not considered to be of particular relevance</p> <p><sup>"E"</sup> earlier document but published on or after the international filing date</p> <p><sup>"L"</sup> document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p><sup>"O"</sup> document referring to an oral disclosure, use, exhibition or other means</p> <p><sup>"P"</sup> document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p><sup>"T"</sup> later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p><sup>"X"</sup> document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p><sup>"Y"</sup> document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p><sup>"&amp;"</sup> document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
14th February 1991	1991 -02- 18	
International Searching Authority	Signature of Authorized Officer	
SWEDISH PATENT OFFICE	 Barbro Nilsson	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	WO, A1, 8600100 (EKA AB) 3 January 1986, see page 8 -- -----	5-9

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 90/00690**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 90-12-28  
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0041056	81-12-02	AT-E- 8916	84-08-15
		AU-B- 546999	85-10-03
		AU-D- 7051481	81-12-03
		CA-A- 1154563	83-10-04
		JP-A- 57051900	82-03-26
		JP-B- 62031120	87-07-07
		JP-A- 62223395	87-10-01
		SE-B- 432951	84-04-30
		SE-A- 8003948	81-11-29
		US-A- 4388150	83-06-14
		US-A- 4385961	83-05-31
WO-A1- 8806659	88-09-07	AU-B- 596285	90-04-26
		AU-D- 1399588	88-09-26
		EP-A- 0304463	89-03-01
		JP-T- 1502519	89-08-31
		US-A- 4964954	90-10-23
EP-A1- 0261820	88-03-30	AU-B- 601215	90-09-06
		AU-D- 7859887	88-04-07
		JP-T- 1501639	89-06-08
		WO-A- 88/02048	88-03-24
WO-A1- 8600100	86-01-03	AU-B- 573360	88-06-02
		AU-D- 4498585	86-01-10
		CA-A- 1250703	89-03-07
		EP-A-B- 0185068	86-06-25
		JP-B- 2019238	90-05-01
		JP-T- 61502338	86-10-16
		SE-A- 8403062	85-12-08
		US-A- 4961825	90-10-09